Guidance Systems for the Visually Handicapped

Progress Report Number 2

Institute for Environmental Education

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GUIDANCE SYSTEMS FOR THE VISUALLY HANDICAPPED

PROGRESS REPORT NUMBER 2

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PROJECT PROGRESS SUMMARY

1.0 PURPOSE

The purpose of this project is to develop and test combined tactile/electronic guidance devices to enhance the direction finding ability and communication between the visually handicapped and the built environment.

2.0 APPROACH

Preliminary testing of guidance devices was conducted at the University of New Mexico Student Union Building and at the New Mexico School for the Visually Handicapped, using blindfolded sighted, partially blind, and totally blind subjects. The tactile/electronic guidance devices are described briefly below:

2.1.0 Electromagnetic Guidance Devices (see also description of electromagnetic devices Appendix D)

2.1.1 Handheld/Audio Feedback - A small hand held device provides audio feedback guiding the subject through a pre-arranged "Null System" type electromagnetic path.

2.1.2 Cane Mounted - A small guidance device mounted to a cane which follows either a "Null System" or "Single Wire Loop" type electromagnetic path. Due to its extended length, the cane allows its user to identify obstacles and path direction changes more rapidly than do other devices. Course correction of travel is easier.

2.1.3 Handheld/Tactile Vibration Feedback - A small handheld guidance device with tactile feedback with similar characteristics as 2.1.1.

2.2.0 Electromagnetic Path Systems

2.2.1 "Null System" - A miniature AM radio transmitter with an electromagnetic loop antenna which provides two continuous tone signals with a "Null Path" signal which the handheld receiver can follow. (see Patent Disclosure Appendix D).

2.2.2 "Single Wire Loop" - Similar to the null system described above, however, with single wire antenna loop with continuous tone audio feedback path.

2.2.3 Beacon - A short range miniature AM radio station located at major intersections or locations along the electromagnetic path. These beacons can emit pre-recorded messages for the user.

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2.3.0 Tactile Mapping - A new generation of tactile maps has evolved from basic research findings gathered from literature research and preliminary testing of prototypes. The maps are greatly simplified when compared with the original tactile building directory for the New Mexico Union (see Appendix C). This "new" generation of tactile map is not unsimilar to (Roman) topological maps (see Appendix C). The new generation schematic maps require fewer symbols and greatly simplify "trip planning", general orientation, and understanding of spatial relationships. Limited and preliminary testing of these maps and associated symbols with blind and partially sighted subjects has been conducted in the Albuquerque area and at the New Mexico School for the Visually Handicapped.

3.0 RESULTS

3.1.0 General Results

No one device or guidance system appears to meet all the needs of persons with different types of blindness. Rather, system components for trip planning (tactile maps), safe tracking (electromagnetic guidance or path system) and orientation (electromagnetic beacons) will have varying degrees of usefulness for different sub-groups in the visually disabled population.

3.2.0 Electromagnetic Guidance Devices

Cane mounted devices were preferred by most test subjects, although some subjects indicated their preference for handheld devices for reasons of unobtrusiveness. As far as display mode is concerned, the tactile or vibrating handheld device was liked by many subjects since it does not interfere with the all-important acoustic environment. Technical difficulties prevented its full exploration so far. (See detailed analysis below).

3.3.0 Electromagnetic Path System

The so-called "Single Wire Loop Systems" appear to perform better than the "Null Systems" tested so far, especially in corners and sharp (90^{o}) turns. While the "Null System" has the advantage of an uncluttered acoustic environment while the subject is on track, its application in buildings with narrow hallways appears to be limited. (See

detailed analysis below).

3.4.0 Electromagnetic Beacons

Only very limited testing has been carried out with beacons to date. There are technical problems to be overcome. For example, beacons used drown out the sound of the electromagnetic path tracking system and lead to disorientation. On the other hand, interviews revealed the desirability of beacons.

3.5.0 Tactile Maps

While they have not yet been tested in a systematic manner, the new generation tactile maps have received very favorable evaluations from a limited sample (18 subjects) of visually disabled persons who inspected the maps and symbols used. The maps (unlike the previous, architecturally true floor plans of the building in question) show in raised imagery only the path of travel and important items of interest along that path (doors, water fountains, rest rooms, elevators, phones, etc). They are indicated through dots which are coded with Braille letters/numbers. Interestingly, the scale of maps appears not to be an issue, according to the subjects questioned. Rather, the spatial configuration of the circulation areas of a building is of interest for memorization.

The preliminary inquiry into preferences for symbols (stairs, entryways, elevators, north directional signs) shows mixed results, although certain symbols appear to communicate better than others (see detailed analysis below).

Overall, tactile maps are considered very useful devices for familiarization with a new or unfamiliar building or area prior to travel in that area.

4.0 OUTLOOK

A major grant application to the U.S. Department of Transportation ($350,000) for a three-year project was made in January, 1982, with the objective of carrying the research into new phases in

which the devices described above would be developed further, including the use of voice synthesis beacons at key locations along travel routes. Miniaturization of devices is another objective.
During the Spring Semester of 1982, the upper floor of the Student Union Building will be permanently wired (the first electromagnetic guidance system anywhere in world) in connection with the new carpet tile installation there. This will serve as a testbed for the evaluation of future guidance devices which will have both audio and tactile display modes, to be used on the "Single Wire Loop"system.
Collaboration with Professor Gary Kelly at Georgia Tech is invisioned. He has developed a digital device (from Sears garage door openers) which permits the "dialing" of such locations as restrooms, phones and stairs which are within a range of 75 to 100 feet. At these locations loudspeakers are mounted which will emit coded signals, chimes, etc. when activated. The well-developed binaural orientation faculty of most visually disabled persons will allow them use of the emitted sounds as homing devices.
It is our intent to continue a comprehensive approach to guidance systems for visually disabled persons, both inside buildings (mostly transportation facilities and public buildings) and in outdoor environments.

APPENDIX

A. Test Data for Electromagnetic Guidance Devices and Path Systems

B. Summary of Tactile Symbol Assessment

C. Tactile Map Sample

D. Patent Disclosure (abstracted) by J. G. Small

A test of mobility aids for the blind was conducted on the campus of the New Mexico School for the Visually Handicapped in Alamogordo, New Mexico. Twelve students and faculty members affiliated with that institution participated in the study. Age and degree of visual impairment varied across subjects. The mobility aids consisted of small radio transmitters and receivers. The transmitter antennae were elongated loops of narrow gauge wire taped to the floor, forming the paths the subjects had to follow. Two types of receiver were used:

1. A small, unmodified transistor AM radio.
2. The same type of radio, mounted on one end of a four foot wooden dowel, the receiving antenna mounted at the other end. In addition, two different types of transmitting antenna configurations were used:

1. A single wire track.
2. A parallel double wire track, the wires four feet apart. The distance and configuration of the paths were identical for both the single and double wire tracks. Each device was used on both tracks, so each subject ran four trials; the order was randomized for each subject.

The signal was an audible single frequency tone received when the receiver was close to the transmitting antenna; the nature of the tracking task varied depending on the receiver-track configuration used. The following is a description of the device-track configurations and how they were used:

1. Cane on single wire track - the tone would be heard when the tip of the cane was within a one foot radius of the wire.
2. Cane on double wire track - the tone was heard when the tip of the cane close to the wires, but the subject had to swing the cane in a broad arc (no signal being received in the middle) to determine if they were on track, i.e., between signals or in the null area.
3. Hand held on single wire track - holding the radio vertically, directly over the wire at waist height, no tone would be heard, but upon shifting to one side or the other, a tone would be heard.
4. Hand held on double wire track - holding the radio horizontally, directly between the two wires at waist height, no tone would be heard; moving or swinging the radio away from the center line caused the tone to be heard.

Each configuration allowed the subjects to follow the designated path, but to determine the relative efficiency of each device, two measures of performance were recorded for each trial: time to complete the route and number of assists needed. An assist was operationally defined beforehand as being required under four conditions:

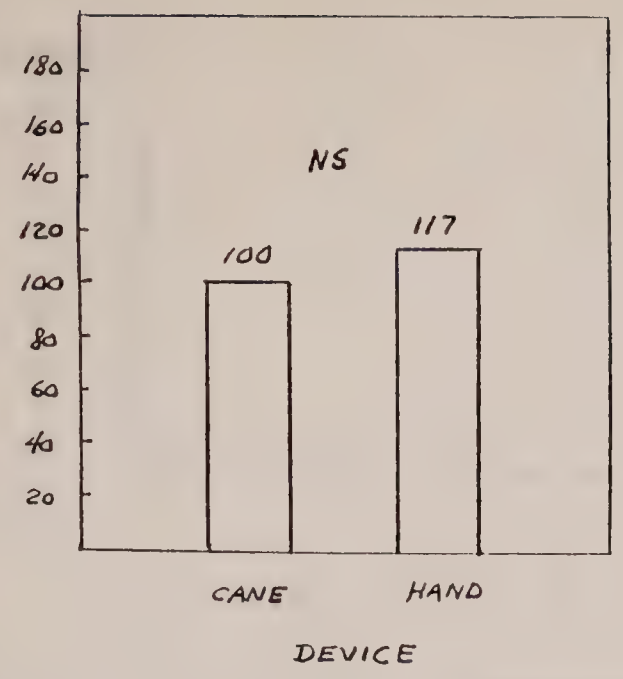
1. If the subject requested assistance (although they were requested to do so only if they felt completely unable to continue).
2. If the subject lost the signal and made no progress for a period of twenty seconds, the experimenter would intervene.
3. If the subject moved two paces in the wrong direction (backwards).
4. If the subject had both feet outside of a four foot wide lane, defined by the wires in the double wire track, and marked on the single wire track.

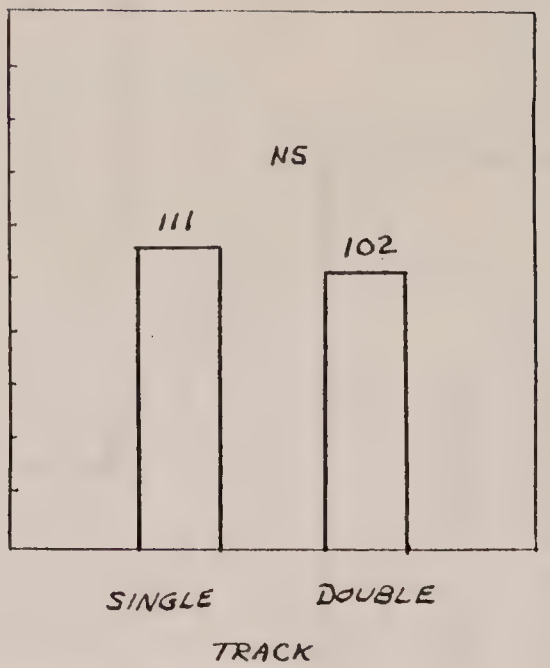
As it turned out, the fourth condition was the only one that occurred. Assistance was given by stopping the subject, moving them back to the point where they left the path, and making sure they were receiving the signal. Timing was stopped during the assist, then continued when the

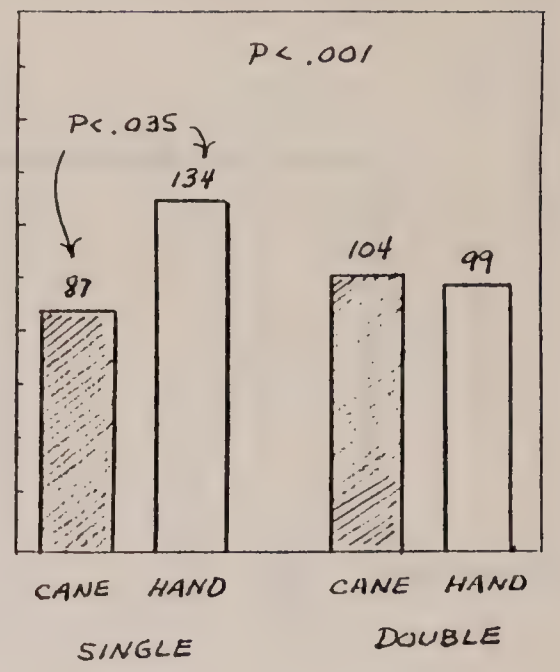
subject resumed the task. The subjects were given time to practice using each device on a seperate track prior to the actual testing.

The mean times to complete the routes for the cane single, cane double, hand held single and hand held double conditions, were, respectively, 87, 105, 134, and 100 seconds. While an overall analysis of variance of the data showed significance for only the device-track interaction, a test of simple main effects indicated that the cane within the single track was significantly more effective than the hand held device. The mean number of assists for the same conditions were, respectively, .75, 3.17, 3.17, and 3.83 per trial. The analysis of variance showed the factors of device and track to be significant, the cane-single track combination clearly being the most effective.

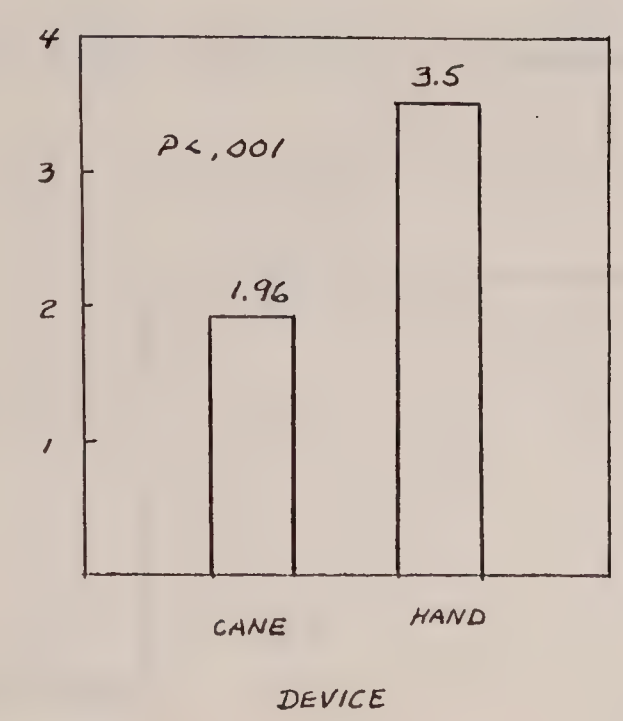
TIME
(SECONDS)

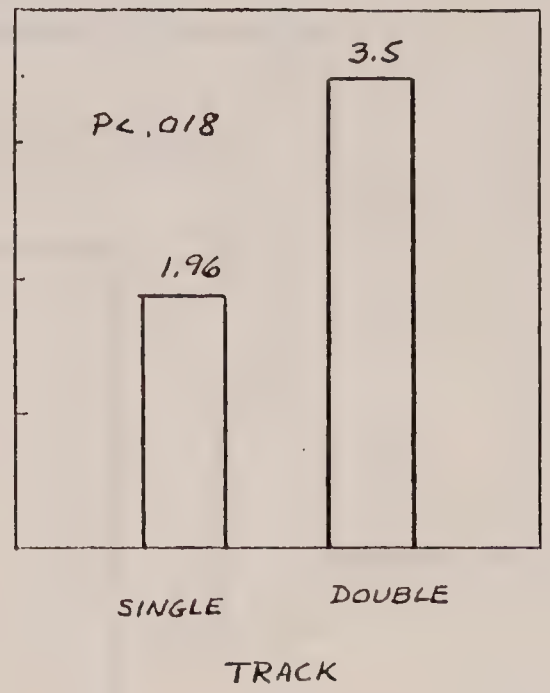


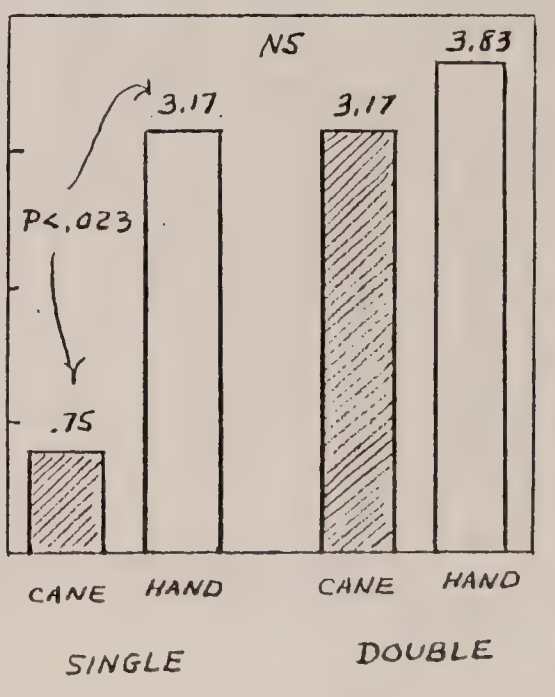




ASSISTS







IS CONSENT FORM SIGNED ?

SUBJECT # 20 ORDER CD, CS, HS, HD

AGE

MALE FEMALE

CANE OTHER

PARTIAL TOTAL

ADVENTITIOUS CONGENITAL

HEARING DEFICITS

MOBILITY TRAINING

TIME

DEVICE

DOUBLE WIRE

TIME

DEVICE

SINGLE WIRE

NOTE ASSISTS WITH AN 'A' ON THE TRACK

Respondents Identification Number:

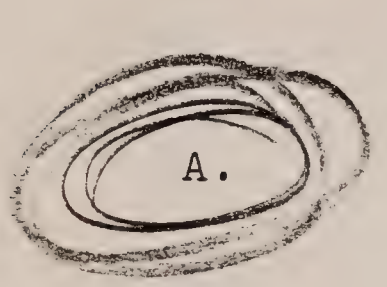
TACTILE BUILDING DIRECTORY SYMBOLOGY QUESTIONNAIRE

The five groups of four tactile symbols to follow are designed to obtain your performance of a variety of symbols which describe the same building component or direction finding device. Please describe your preference of these symbols in rank order from most favorite or most uderstandable symbol to least favorite or least understandable symbol.

Sheet 1

1.0 The four symbols indicated below graphically and tactually represent stairways

A.



B.

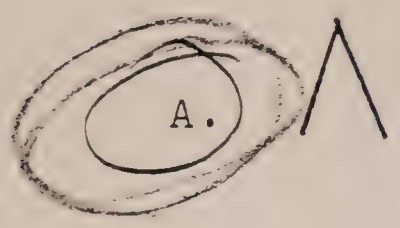
C.

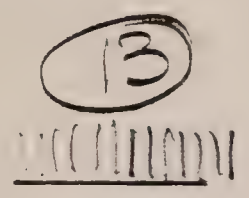
D.

Other: _____

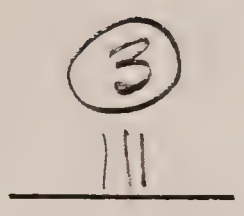
1. Dots on C are steps
2. B could be used for dead end symbol
3. A crosslines good for stairs / rate of steps to symbol steps
4. A or C because they feel like stairs
5. A points up & Down to landing
6. B most distinguishable
7. D should be more jagged

2.0 The four symbols below both graphically and tactually represent North arrows to help orientation to a tactile building directory

A. 

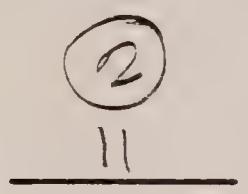


B. 



C. Indicates a North dot at the upper right of the map. _____

D. 

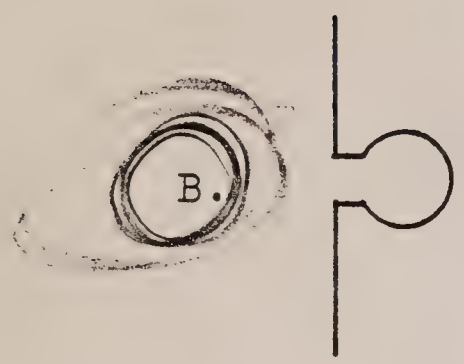


Other: _____

1. Simple symbol
2. A too plain D is too bold
3. D looks more like Arrow
4. B dot? points direction
5. Braille is best
6. A Use letter A shows angles best

3.0 The four symbols below indicate both graphically and tactually door openings along a path

A.



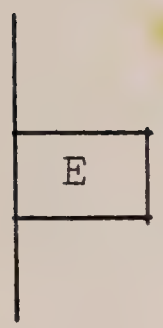
C.

D.

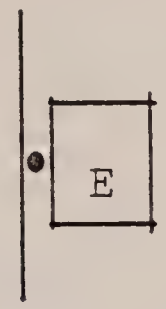
Other: _____

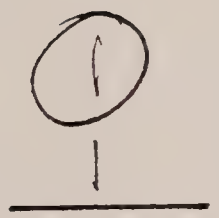
1. B may be good for hallway turn
2. Similar to a K
3. D direction tells you where to go
4. B label opening
5. B easiest to tell opening
6. A with larger dots
7. BShows an opening

4.0 The four symbols to follow represent elevators



B.





C.

Other: _____

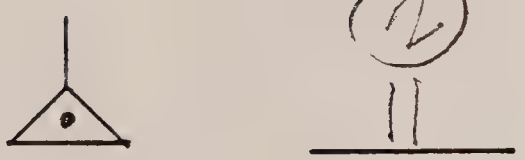
1. A takes less space
2. D is more obvious
3. D seems easier to read
4. D idea that it opens up
5. Print letters more to be used
6. D if opening onto hall
7. B if going thru doors
8. the simpler the better
9. A or D both good

5.0 The four symbols to follow indicate either building entrys or the beginning of a tactile path

A. 

B. 

C. 

D. 

Other: _____

1. B used for building entry
2. How you read A is critical

NEW MEXICO UNION
UPPER LEVEL

TACTILE BUILDING DIPECTORY

SECOND GENERATION
TACTILE MAP PROTOTYPE

APPENDIX D: Abstracted Patent Disclosure by Prof. Dr. J. G. Small (10/22/81). Department of Physics, University of New Mexico.

ELECTROMAGNETIC NAVIGATION AIDS FOR THE VISUALLY HANDICAPPED.

Background:

Recent research by Prof. W.F. E. Preiser of the School of Architecture and Planning and by Prof. Mark Brecht of the Psychology Department has indicated that blind persons have more difficulty negotiating the interiors of buildings than they have going from one building to another out-of-doors. The work of Preiser and Brecht to devise a tactile map of building interiors inspired the present invention. The novel idea contained in this disclosure is a simple system of electromagnetic navigational cues which may be used either indoors or our-of-doors. A working prototype has already been constructed and appears very promising.

With presently available electronic components, it is a simple matter to build very low powered radio transmitters operating at frequencies in the standard AM broadcast band. Such transmitters are considered "limited radiation devices" by the Federal Communications Commission and do not require licensing. These devices are occasionally used to broadcast information to motorists along highways (Interstate 8 west of Phoenix, AZ) or in parking lots (Disney World in Orlando, Florida) or to pedestrians on walking tours (Carlsbad Caverns, NM). The range of the transmission depends on transmitter power and antenna configuration.

Point Source Beacons:

Such a transmitter has been constructed operating on a frequency of 833 kilohertz and amplitude modulated by a continuous audio frequency tone. When using a circular wire loop antenna of diameter approximately 10 cm, the transmission may be received at a distance of 2 meters or less by a common hand held transistor radio. In this embodiment, the device may be considered as a point source beacon transmitter of very short range. Such beacons could be used to mark points of interest to blind persons, for example the tops and bottom of stairways, corners of buildings, rest rooms, etc.

Pathway Marking:

The same transmitter with a different antenna configuration can be used as an electromagnetic pathway for the blind. The antenna may take the form of a long rectangular loop of width approximately 2 meters and length up to many hundreds of meters. As one approaches the loop with a hand held receiver, a signal of increasing strength will be detected within a few meters of the antenna loop. However, when passing the precise center of the loop there is a sharp null in the signal strength for an appropriate orientation of the receiver antenna. The position of the center of the loop may readily be found to an accuracy of a few centimeters by moving the receiver back and forth by hand.

The null effect can be used to establish electromagnetic pathways for the blind. Antenna loops may be placed beneath carpets, overhead in ceilings, along walls, or beneath out door pathways. The pathways may be straight or

curved. The pathways may be followed by a common hand held transistor radio to an accuracy of a few centimeters. The path is followed by moving the receiver from side to side and searching for the null in a manner similar to a blind person's use of a white cane.

Different pathways may be encoded by different program material on the radio transmissions. The simplest embodiment is to use different tones for different paths. Other possibilities are to use recognizable sounds such as music or voices. Points of interest along the pathway, such as names of buildings or location of rest rooms, could be announced by point source beacons with repeating voice messages or distinctive sounds.

Potential Applications:

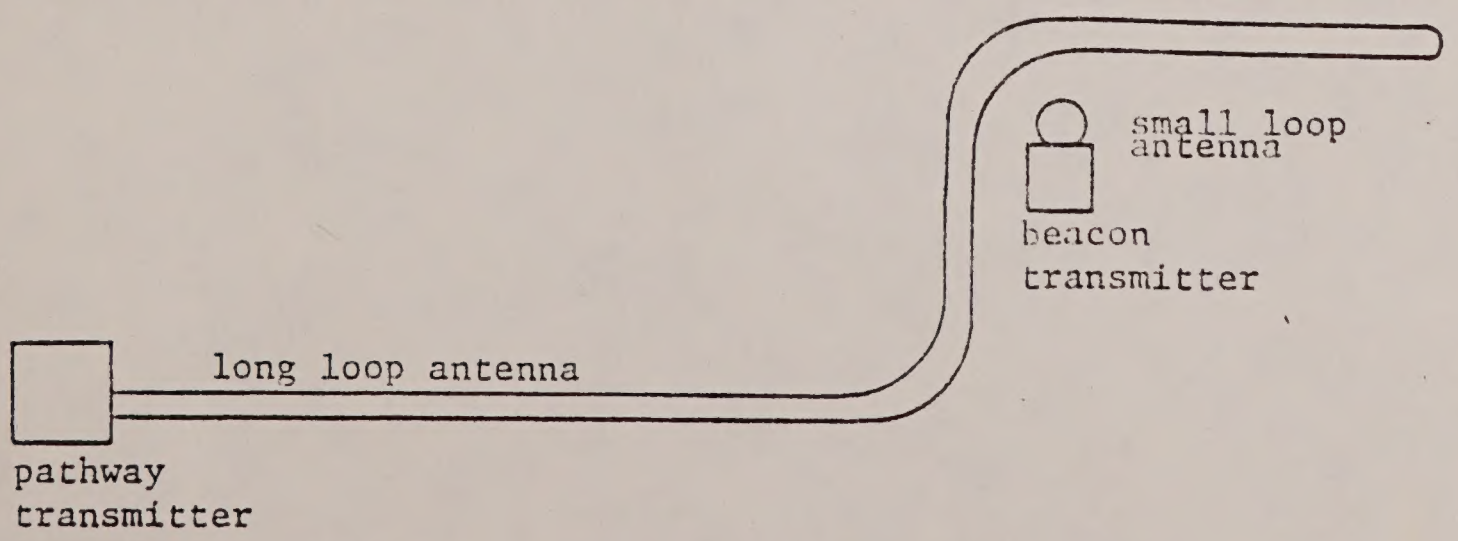
Much research of an operational and psychological nature will doubtless be required to specify the most useful embodiment of this invention. It is possible, for example, to devise a more complicated receiver which would automatically search for the null path and then push or nudge the user in the appropriate direction. The user would be relieved of a possibly tedious process of listening to a tone and searching for a null by hand. The trade-off for this convenience is a more expensive receiver.

An electromagnetic pathway could be established around an athletic oval or track. It may then be possible, for the first time, for the blind to jog and participate in foot races.

The blind often want to know the four cardinal compass directions. Having once been exposed to transistor radio direction finding, they will find that the same radio which is useful for following pathways can also be used to determine the direction to local radio stations around the city. This type of radio frequency direction finding could substitute for magnetic compass readings.

Once electromagnetic pathways are in place, it is a simple matter to build machines which can follow the paths. A robot courier service would be straightforward to implement.

The electromagnetic pathways could be useful to sighted persons in unfamiliar places with complicated geometries such as large train stations or public buildings. They could follow simple paths. Alternatively, the path following could be automated as with a robot courier. A hand held device containing a microprocessor could tell the user by synthesized voice circuitry where he is and which way to turn at each intersection.



Note: Some of the ideas expressed herein have since been reconsidered and updated.